Space Weather Technical Forecast

Issued on Tuesday 25 February 2025 at 01:12 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares likely. Chance of G1/Minor geomagnetic storm on Day 1 (25 Feb) due to ongoing enhancements. S1/Minor radiation storm expected on Day 1.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with four M-flares, the largest a long duration M3.9 flare peaking at 24/2306 UTC, from over the western limb. There are currently nine sunspot regions on the visible disc. The most notable regions remain AR3998 in the southwest quadrant and AR4000 in the northwest quadrant. AR3998, although large, has remained stable, with perhaps some minor grouping of the intermediate spots. AR4000 has shown signs of some decay in the intermediate portion of the group, but with the weak delta spot still remaining visible. AR3996 continues to appear to be in slight decay, with most intermediate spots appearing to have faded. AR4006 in the northeast appears to be another larger spot region, with a cluster of mature spots on its leading portion. The other regions on the disc do not currently appear particularly complex and are generally stable.

A CME was observed to the southwest in association with the long duration M3.9 flare from over the west limb. To be determined if there is any Earth-directed component, with analysis pending.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE at L1, showed background conditions at first, before fluctuating between slightly elevated and background levels from 24/1800 UCT. Wind speeds varied through the period between 320-460 km/s. Density was initially around average, becoming above average between 24/0830-1100 UTC. Interplanetary Magnetic Field, Bt, was predominantly moderate, ranging between 3-17 nT. The north-south component, Bz, was mostly positive, varying between weak and moderate. It did have one sustained negative period, where it reached -13 nT. Phi angle was mostly positive (away from the Sun), but became negative (towards the Sun) between 24/0900-1800 UTC. Geomagnetic activity was Quiet to Active (Kp1-4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 rose from 24/2300 UTC, becoming close to the S1/Minor radiation storm threshold, in response to the long duration M-flare mentioned above. High energy electron flux (greater than 2MeV) at GOES16 was at background levels. The associated 24-hour fluence was below the Active threshold (1e8 integrated pfu) on a slight declining trend, recording 1.56e6 integrated pfu at 25/0000UTC.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is forecast, with occasional M-flares considered likely and a slight chance of isolated X-flares.

Solar Wind / Geomagnetic Activity: Ongoing enhancement of the solar wind environment is likely as a result of recent transient CME arrivals, as well as some possible influence from CH17/-. No other CMEs feature in the forecast, with the CME off the northwest limb around 24/0600 UTC reassessed as a far-sided event. Any influence from CH17/- is expected to wane after Day 1 (25 Feb). The larger trans-equatorial CH19/+ is then expected to become geoeffective from Day 4 (28 Feb) and beyond, with wind speeds of 600 km/s possible.

Geomagnetic activity is forecast to be Quiet to Active (Kp2-4) at first, with a chance of G1/Minor storm (Kp5) intervals and a slight chance of G2/Moderate storm (Kp6) intervals on Day 1 (25 Feb), due to the effects of weak CME arrivals and possible connection to CH17/-. Activity then gradually easing back to Quiet to Unsettled (Kp1-3) from Day 2 (26 Feb). From Day 4 (28 Feb) a connection to CH19 looks likely, with an increasing risk of Active intervals.

Energetic Particles / Solar Radiation: High energy proton flux is expected to be above the S1/Minor radiation storm threshold on Day 1 (25 Feb), in response to the long duration M-flare from over the western limb. The risk easing slightly over the following days. Any further large flares from regions in the western hemisphere may prolong the chance of S1 thresholds being met. High energy electron flux is expected to be mainly at background to moderate levels. The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

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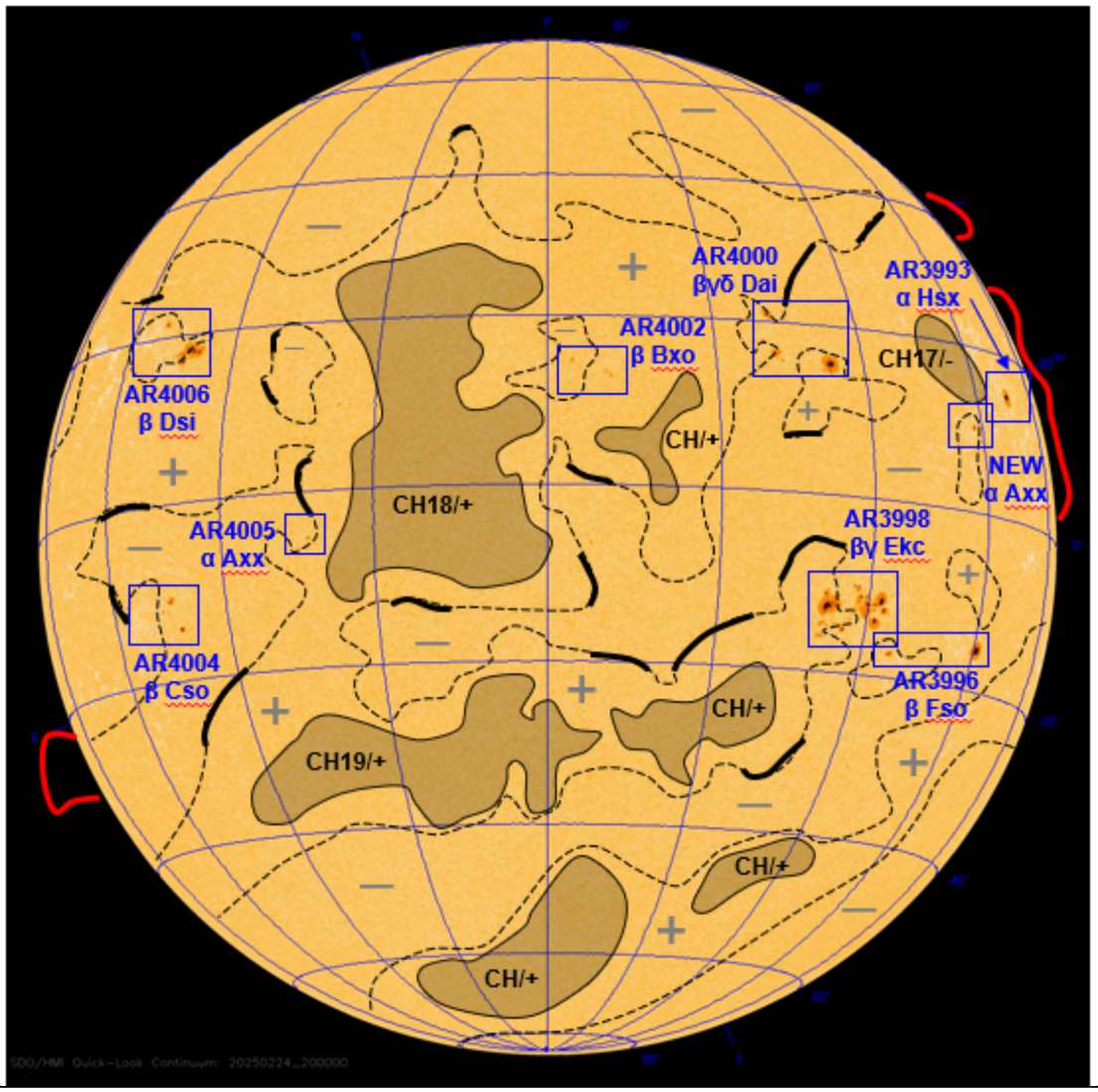
Figure 1: Solar Synoptic Map valid 24/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Enhancement to the solar wind environment continues, likely as a result of weak transient CME arrivals that had been forecast to arrive over the past couple of days, as well as a possible weak connection to CH17/-. No other CMEs feature in the forecast, with the CME off the northwest limb from around 24/0700 UTC reassessed as a far-sided event, with no Earth-directed component. A CME off the southwest limb in association with the long duration M3.9 flare at 24/2306 UTC (and associated Type II & IV radio emissions), is unlikely to have any Earth directed component also, pending analysis.

Wind speeds are currently fluctuating between background and slightly elevated, around 390-440 km/s. As mentioned above, one reason for this increase may be in part to CH17/-, a small, weak feature seen in imagery. As CH17 is negative polarity and the March equinox is approaching, if a lasting connection occurs there may be a slightly greater geomagnetic response to a weak High Speed Stream (HSS) than normally expected. This feature is only likely to be geoeffective on Day 1 (25 Feb). From Day 4 (28 Feb) and beyond, a connection to the large trans-equatorial CH19/+ looks likely. This is a persistent feature, with winds speeds expected to become strong, perhaps around 600 km/s. There is some uncertainty as to the onset of this HSS, with a smaller coronal hole forming ahead of this larger feature, which could see an earlier rise in solar wind speeds before a connection to CH19. Other coronal holes situated in the southern hemisphere may also come into play, however these are fairly well south so any strong connection may be unlikely. Enlil is too quick with the onset of these faster winds.

Geomagnetic activity is forecast to be Quiet to Active at first, with a chance of G1/Minor storm intervals and a slight chance of G2/Moderate storm intervals on Day 1 (25 Feb), due to the effects of weak CME arrivals and possible connection to CH17/-. Activity then gradually easing back to Quiet to Unsettled from Day 2 (26 Feb). From Day 4 (28 Feb) a connection to CH19 looks likely, with an increasing risk of Active intervals.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	10	5	20
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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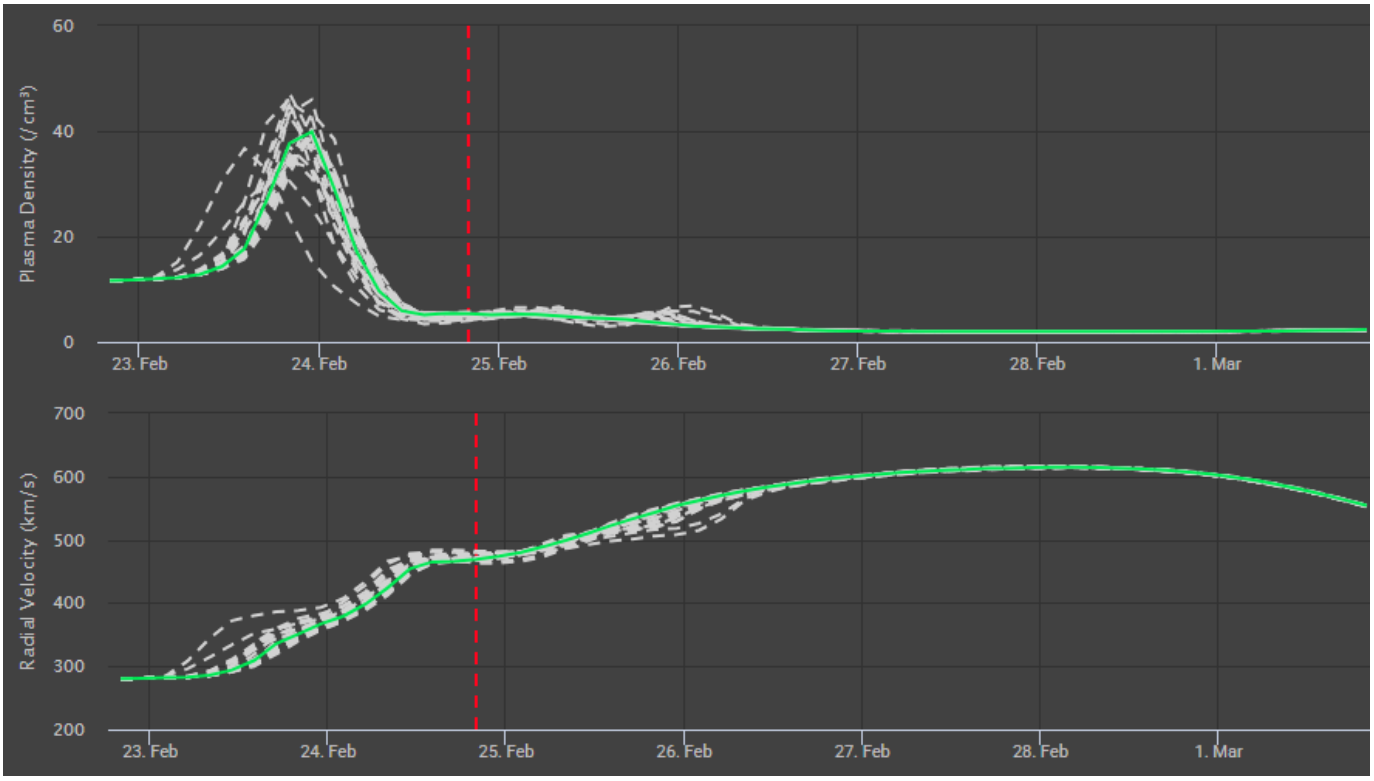
Figure 2: MOSWOC Ensemble model. Note that onset of fast winds likely too early.



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Radio Blackouts - X-Ray Flares

Solar activity has been Moderate with four M-flares, the largest a long duration M3.9 flare peaking at 24/2306 UTC from over the W limb, possibly from Ex-3991.

There are currently nine sunspot regions on the visible disc. The most notable regions remain AR3998 in the southwest quadrant and AR4000 in the northwest quadrant. AR3998, although large, has remained stable, with perhaps some minor grouping of the intermediate spots. AR4000 has shown signs of some decay in the intermediate portion of the group, but with the weak delta spot still remaining visible. AR3996 continues to appear to be in slight decay, with most intermediate spots appearing to have faded. AR4006 in the northeast appears to be another larger spot region, with a cluster of mature spots on its leading portion. This region, and others in the far east, will become easier to analyse over the coming days. The other regions on the disc do not currently appear particularly complex currently and are generally stable.

Moderate solar activity is forecast, with M-flares considered likely and a slight chance of isolated X-flares. There are possibly one or two historic regions due to return around the eastern limb in the next day or so, but far side seismographs are not detecting any significant regions near the east limb. As such the probabilities have been kept flat through this period pending further developments.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	70	70
Very Active	R3-R5 (X Class)	No	10	10	10	10

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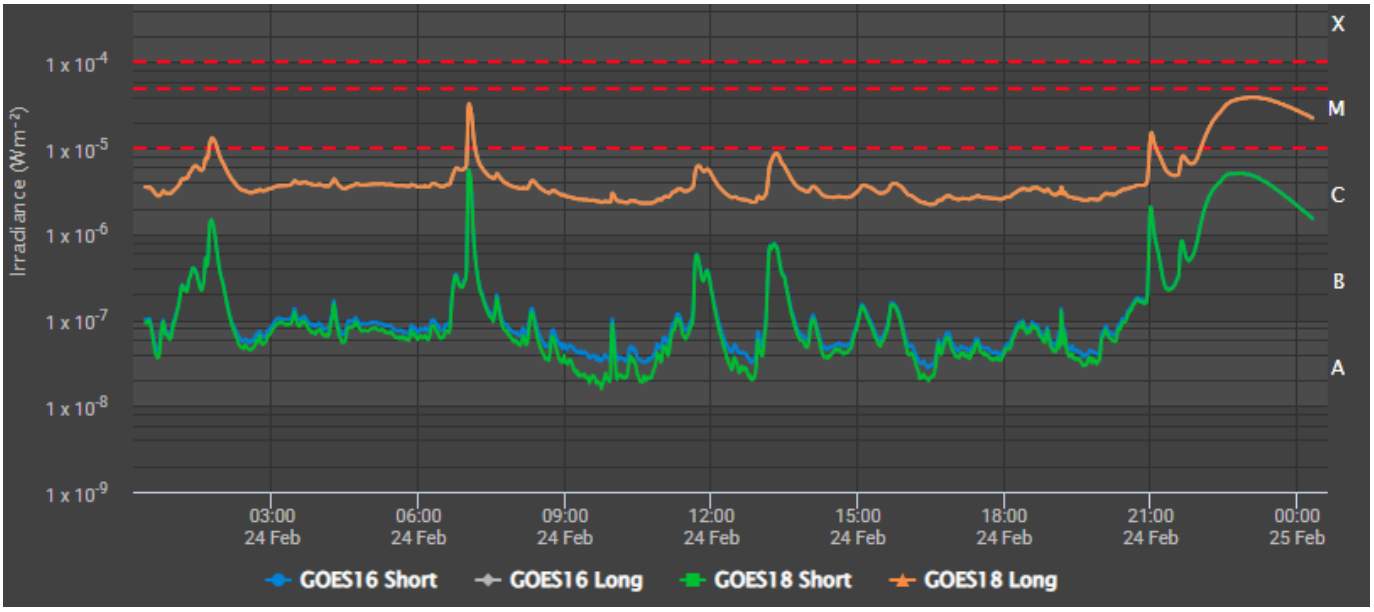
Figure 3: GOES-16 & -18 X-ray flux.



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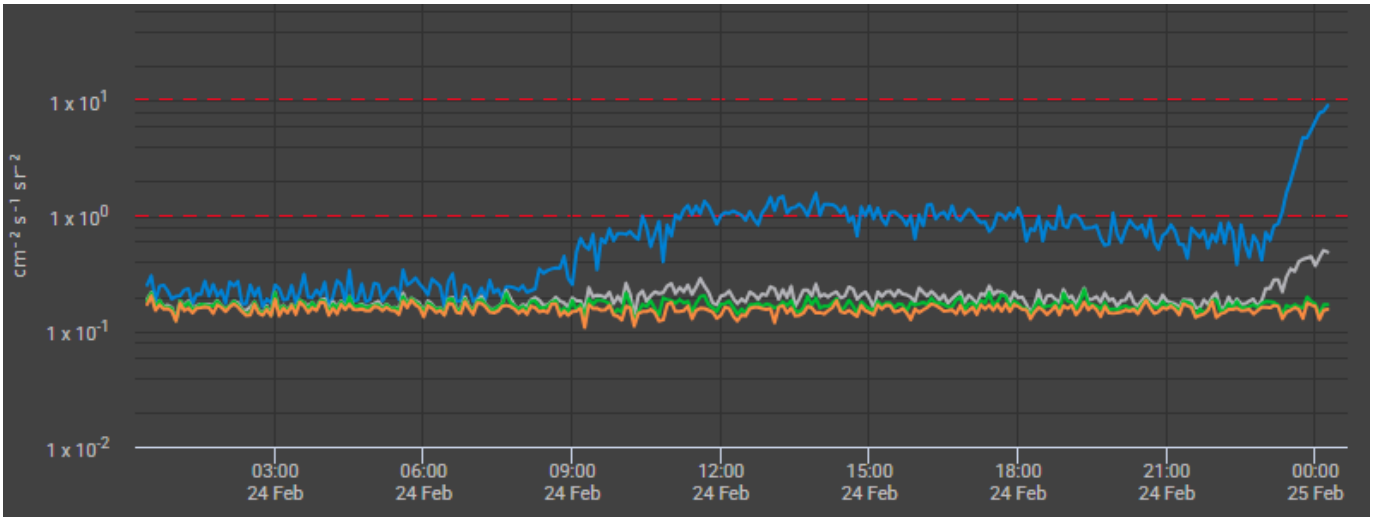
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux is rising in response to flaring from the western hemisphere. An initial small increase was most likely as a response to the M3.3 flare at 24/0702 UTC from AR4000, or perhaps from a delayed response to the X2.0 flare at 23/1927 UTC from over the NW limb. A subsequent larger increase has occurred from 24/2300 UTC as a response to the long duration M3.9 flare from over the western limb.

Overall, this results in an expectation that the S1/Minor radiation storm threshold will be met on Day 1 (25 Feb), with the risk easing slightly over the following days. Any further large flares from regions in the western hemisphere may prolong any S1 thresholds being met.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	99	70	50	40
Very Active	**≥ S3 ***	No	10	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 Proton flux.



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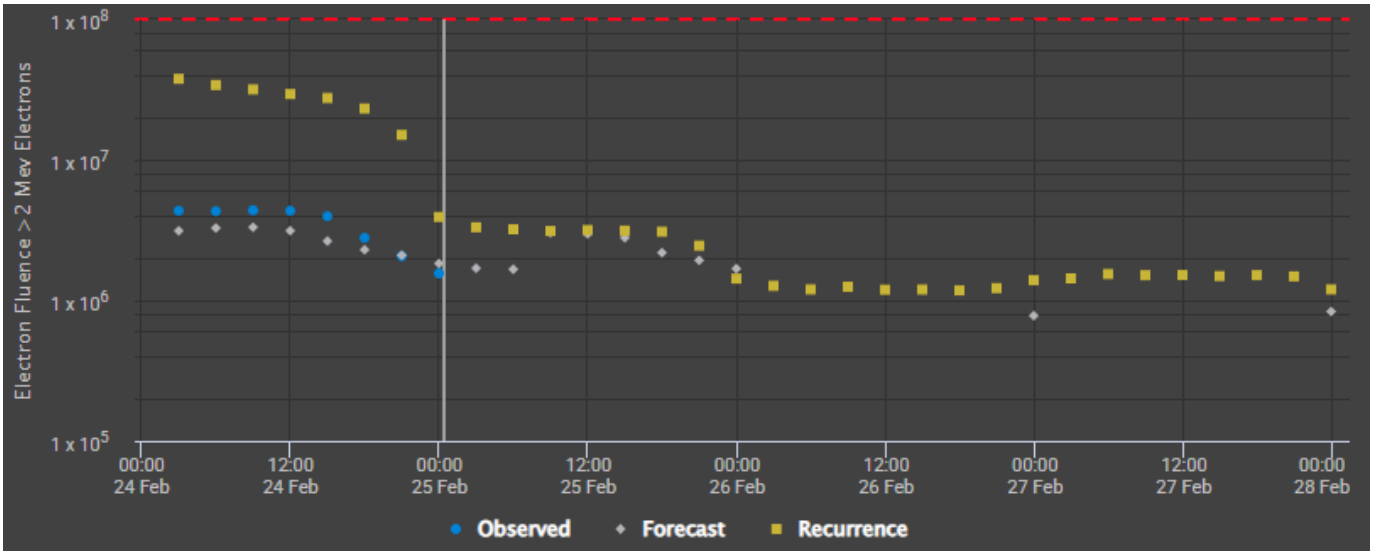
High Energy Electrons (≥ 2MeV)

High energy electron flux, as observed at GOES-16, is at background levels, with recent weak CME arrivals perhaps helping to suppress electron flux. With no major source of charging of the electron belts expected over the coming days, electron flux is expected to remain at similar levels.

The associated 24 hour fluence is currently below the Active level, with a slight declining trend. This is expected to continue as suggested by MOSWOC REFM, which appears to be providing reasonable guidance at this time.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM model, providing good guidance currently.



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